3.33 Fire Rate (Burst) Control Functional Element Sensitivity

Subroutine BURST is used when it is time to start a new firing burst from the guns. It determines how many rounds will be fired (the duration of the burst), calculates the point in time that each round should be fired, and stores these times in an array called SHELLQ. After each burst, there is a short rest period for cooling the gun barrels. The point in time when this rest is over is also calculated and stored in REST. The number of rounds fired is determined by the following equation:

$$n = 4\left[S_{\min} + f_1\left(S_{\max} - S_{\min}\right)\right]$$

where:

$S_{\min}$ and $S_{\max}$ are the minimum and maximum number of rounds fired in a burst per gun

f_1 is a constant between 0.0 and 1.0 which specifies the type of burst (short = 0.0, medium = 0.5, and long = 1.0)

4 is the number of guns

There are two sets of $S_{\min}$ and $S_{\max}$ values, one for close target range and one for long target range. The number of rounds fired is never allowed to exceed the number available (stored in variable TOTSHL). The points in time when the rounds are to be fired are calculated according to:

$$t_i = T + \left(\frac{i}{4f}\right), \; i = 1, n$$

where: t_i= the moment when the i^{th} round is fired

T= the time the burst starts

f = the fire rate of one gun (rounds/s)

n = the number of rounds fired in the burst

Finally, the point in time when the rest is over is determined by:

$$REST = t_n + R_{\min} + f_2\left(R_{\max} - R_{\min}\right)$$

where:

$R_{\min}$ and $R_{\max}$ are the minimum and maximum allowable rest durations

f_2 is a factor between 0.0 and 1.0 which specifies the type of rest (short = 0.0, medium = 0.5, and long = 1.0)

Data Items Required

Data Item		Accuracy	Sample Rate	Comments
9.1.1	Burst control length	±0.1 s	SV/T	
9.1.2	Rest control length	±0.1 s	SV/T	
9.1.3	Number of rounds fired	±1	SV/T	

3.33.1 Objectives and Procedures

Burst control is sensitive to aiming solution outputs and is affected by target position and velocity. Burst and cooling periods are operator-selected. The method for parametric sensitivity of this FE was to exercise *RADGUNS* for the following conditions:

a. Model mode: SNGL/RADR/LLL

b. Target presented area: 25 m^2

c. Target altitude: 200 m

d. Flight path: LINEAR

e. Radar type: RAD1

f. Guns: Enabled, 23 mm

g. Burst length: Short, medium, long

h. Rest length: Short, medium, long

i. Output: Number of rounds fired and P_H over time

A sensitivity analysis was conducted to determine the variation in expected number of hits relative to burst and rest intervals. The matrix below was used to derive the data. Each burst type was paired with all 3 types of rest intervals.

Burst Types	Rest Types	Length (s)	Rounds per Burst	Dependent Variables
Short Medium Long	Short Medium Long	0.60 0.90 1.20	40 60 80	(1) Number of Rounds per burst (2) Expected Number of Hits

3.33.2 Results

The nominal gun firing rate is 4000 rounds/min, or 66.67 rounds/s. In the procedural chart above, a 0.3-s increment in time results in a 20 round change in burst size. This factor indicates the need for precise time measurements and round counts. The level of precision indicated will likely require sophisticated optics coupled with time measurement equipment capable of accuracies on the order of ±0.05 s. Table 3.33-1 matches the number

of expended rounds to each permutation of burst length and rest interval for identical engagement scenarios. Table 3.33-2 is a comparison of expected hits as a function of burst and rest types.

TABLE 3.33-1. Number of Rounds per Engagement.

Burst\Rest	Short	Medium	Long
Short	882	542	400
Medium	1064	717	540
Long	1161	800	640

TABLE 3.33-2. Number of Expected Hits per Engagement.

Burst\Rest	Short	Medium	Long
Short	80	50	34
Medium	96	59	42
Long	100	68	60

Figures 3.33-1 and 3.33-2 graphically depict the data from the previous two tables. As expected, longer burst lengths and shorter rest intervals result in a greater number of rounds expended and a corresponding increase in expected number of hits. Number of rounds expended per engagement requires accuracies of ±20; expected hits require measurement precisions of ±4.

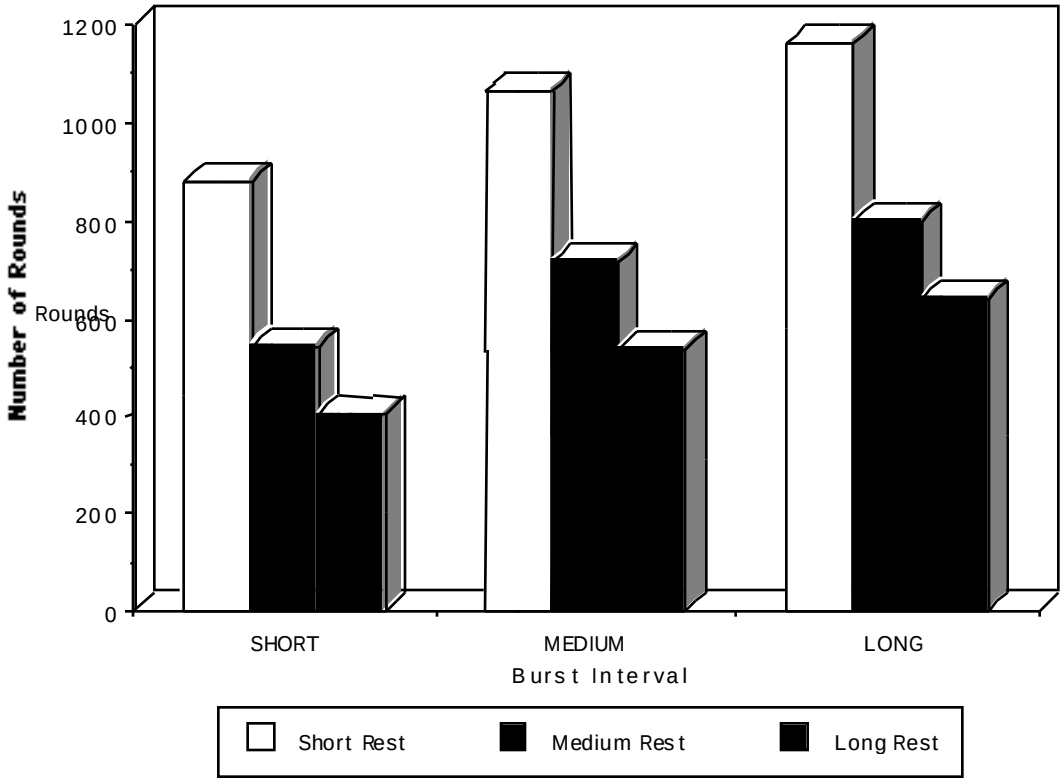

FIGURE 3.33-1. Number of Rounds per Engagement.

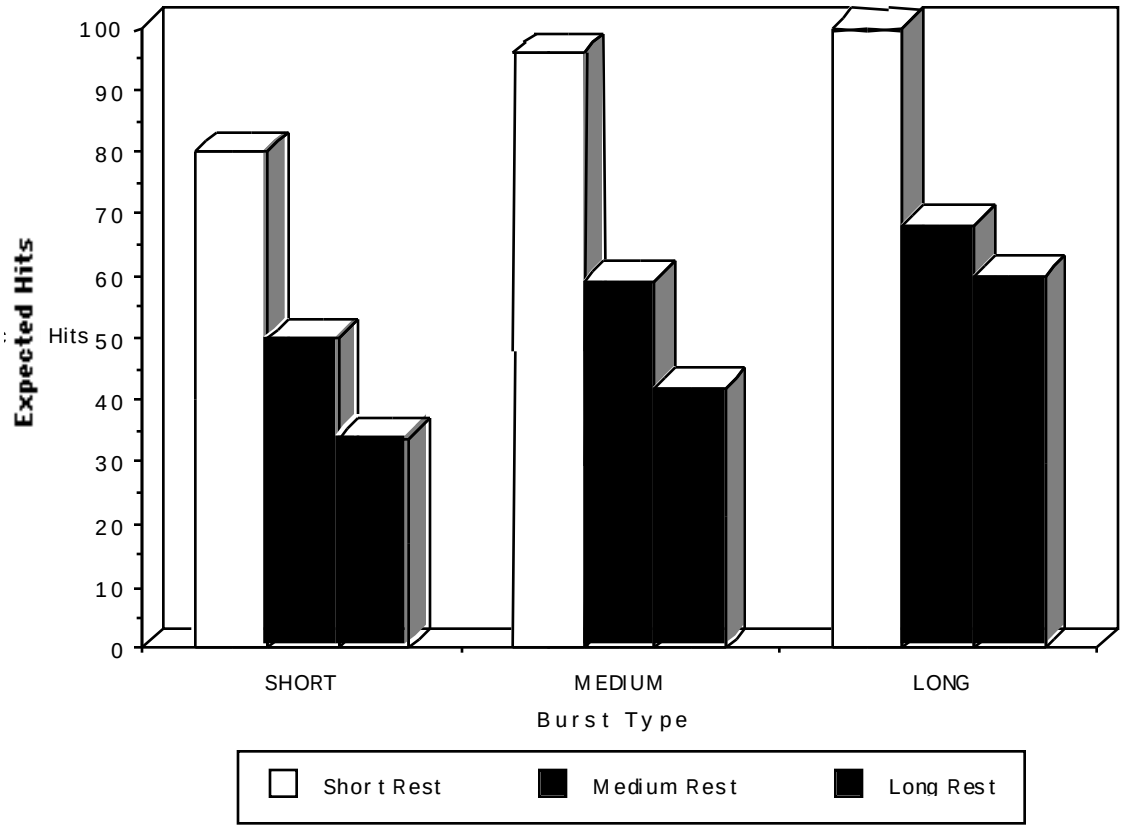

FIGURE 3.33-2. Expected Hits per Engagement.

3.33.3 Conclusions

A change in burst or rest type (S, M, or L) results in a nominal 33% change in rounds per burst (which is proportional to expected number of hits). This sensitivity is in the medium range, with a normalized sensitivity ratio of 1.00.